SAND 98-0027A

PROPENSITY FOR SPALL FORMATION IN SALT STORAGE CAVERNS USING A CREEP AND FRACTURE ANALYSIS*

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Abstract: There are a relatively large number of hydrocarbon, gaseous and liquid, as well as basic feed stock, storage caverns in the U.S. These storage caverns are often constructed in massive salt deposits by dissolutioning of the salt. Immense caverns with capacities of millions of barrels are formed this way. In storage caverns, liquids are normally transfer by brine displacement through very long, often several thousand feet, hanging strings of casing. Many well documented hanging string events have occurred in the storage caverns of the Strategic Petroleum Reserve (SPR) in the Gulf Coast salt domes, suggesting impact damage and loss of casing in many instances is the probable result of salt spalls falling in the cavern. Indirect evaluation of the cavern conditions indicate that the greatest occurrence of damage is associated with those caverns with very large rates of accumulation of salt material, presumably from salt falls. The salt certainly comes from the sides of the cavern and is primarily masses that are too small to cause damage. Only a few of the salt spalls are sufficiently massive to damage the hanging casing, and only a few actually hit the casing string. While the salt falls are thought to cause the damage, the propensity for these falls varies markedly between the storage facilities in the different salt domes, and also within the caverns of a given dome. In an attempt to explain these differences, it was necessary to look for a fundamental model of salt fall formation. The Multimechanism Deformation Coupled Creep (MDCF) [1] model of creep and fracture is believed to offer the proper type of response. One aspect of the model is that the amount of time dependent material damage is strongly related to impurity content of the salt, which potentially explains the marked variation between the different dome sites, and the caverns in a given dome. The impurities in a salt dome are non-uniformly distributed, with relatively local concentrations. Impurity levels of the domes also differ. Using this as a basis, a series of calculations were performed using a finite element code and the MDCF model. Smooth wall caverns, under typical cavern geometries and operation conditions show little material damage. It is necessary to have protrusions and irregularities of the cavern wall to produce sufficient damage, and potential spall features. Two cases of idealized protrusions are examined, which produce the conditions for spall.

[1] Chan, K.S, D.E. Munson, A.F. Fossum, and S.R. Bodner, Int'l. J. Damage Mech., 5, 125-140, 1996.

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* Work supported by U.S. DOE under contract DE-AC94-A185000

**A DOE facility, operated by Sandia National Laboratories division of Lockeed Martin

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